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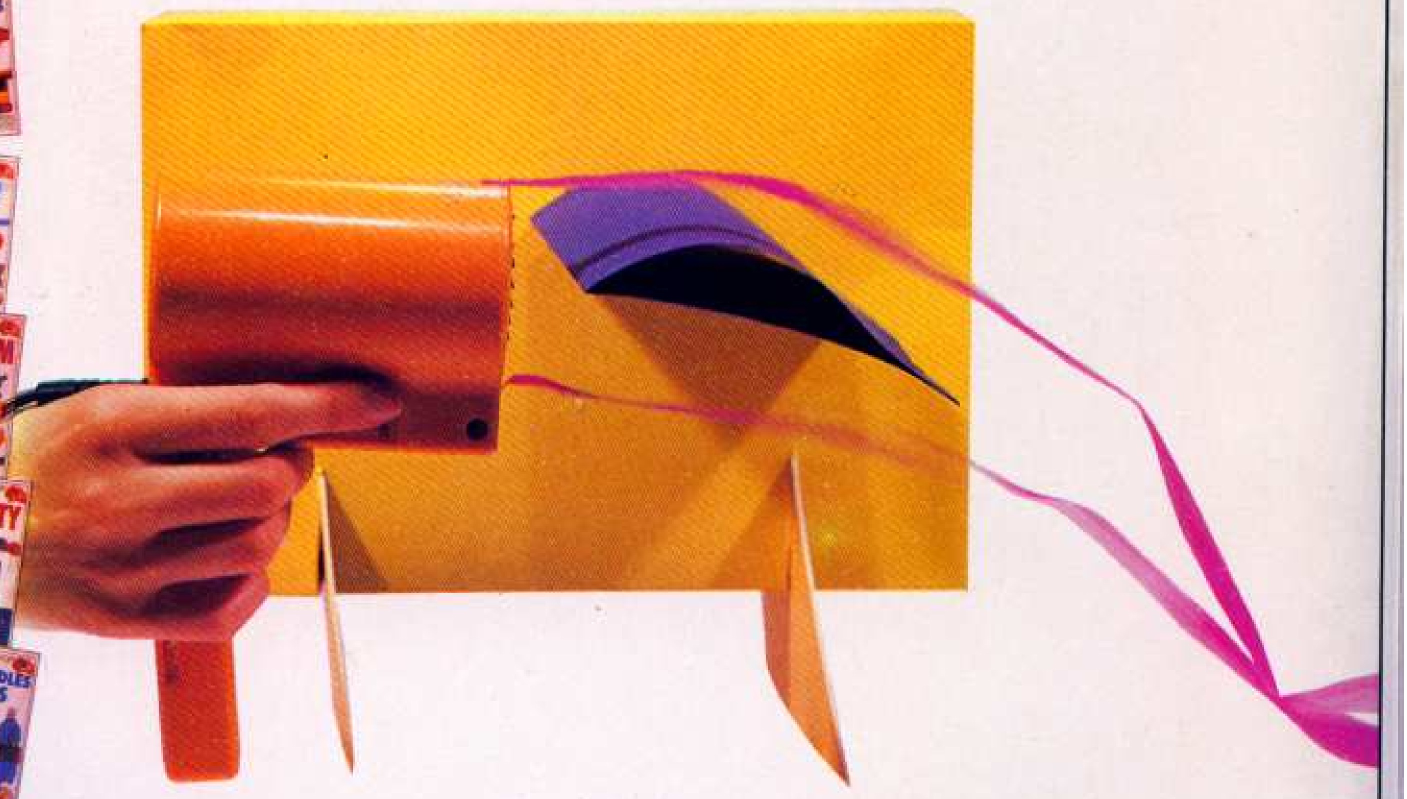

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INTRODUCTION

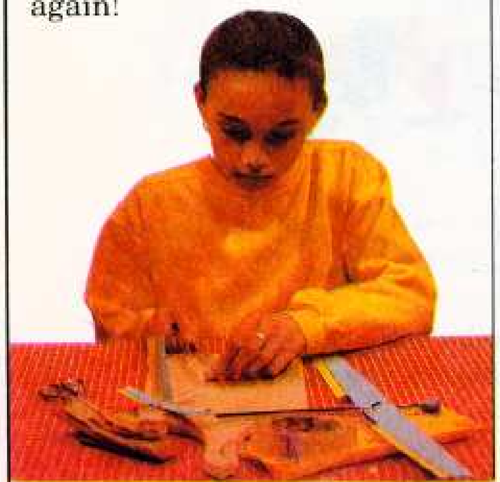
Air is all around us. Even though we cannot see it, taste it or grab hold of it, air is essential to life on Earth. Invisible air is not empty space. It is actually a rich mix of many different gases, including the oxygen that we breathe. The blanket of air surrounding our planet is thick and heavy. Indeed, air exercises pressure on us from every direction. We measure changes in this pressure to forecast the weather. Movements of hot and cold air, which make gentle breezes and fierce hurricanes, can be used to launch a hot air balloon. Changes in air pressure, made by the delicate curve of wing, make flight possible, while the resistance of air is made use of in a parachute, for safe landing. The power of wind can be trapped by windmills to drive machines, and by sails to propel boats. The gases in the atmosphere can be compressed to fit into a smaller volume. This allows large amounts of air to be stored, for example, in small metal cylinders such as the aqualungs used by divers to breathe underwater. Plentiful and fascinating the study of air promises new scientific and technological discoveries in the centuries to come.

THE LABORATORY

A science laboratory is a place to test ideas, perform experiments and make discoveries. To prove many scientific facts you don't need a lot of fancy equipment. In fact, everything you need for a small laboratory can be found around your home or school. Read through these pages, and then use your imagination to add to your "home laboratory". Make sure that you are aware of relevant safety rules, and look after the environment. A science experiment is an activity that involves the use of certain basic rules to test an hypothesis. A qualitative approach involves observation. A quantitative approach involves measurement. Remember, one of the keys to being a creative scientist is to keep experimenting. This means experimenting with equipment as well as with ideas and building up your laboratory as you proceed.

MAKING MODELS

Before you begin, read through all the steps. Then make a list of the things you need and collect them together. Next, think about the project so that you have a clear idea of what you are about to do. Finally, take your time in putting the pieces together. You will find that your projects work best if you wait while glue dries or water heats. If something goes wrong, retrace your steps. And, if you can't fix it, start all over again. Every scientist makes mistakes, but the best ones know when to begin again!



GENERAL TIPS

There are at least two parts to every experiment: experimenting with materials and testing a science "fact". If you don't have all the materials, experiment with others instead. For example, try a plastic drinks bottle if you can't find a washing-up liquid container. Once you've finished experimenting, read your notes thoroughly, think about what happened, and evaluate your measurements and observations. What conclusions can you draw from your results?

Safety Warnings

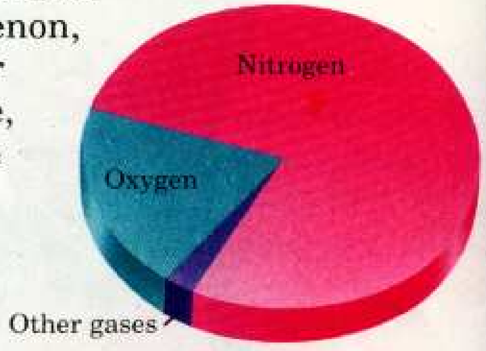
Many of these experiments use a hair dryer. Always be careful when plugging and unplugging it. Never use a hair dryer near water. Don't keep it on for two long, lest it should overheat. Experiments with candles should be done with an adult standing nearby. Don't leave models or equipment directly on a heater. Clean up your laboratory when you finish!

Experimenting

Always conduct a "fair test". This means changing one thing at a time in each stage of an experiment. In this way you can always tell which change caused a different result. Make complete notes as you go along. Ask questions such as "why"? "How?" and "what if?" Then test your model and write down your answers.

Essential Oxygen

Everything around us is either a solid, a liquid or a gas. Gases are the lightest (or least dense) of all. Solid things, like cars, can move through gases. The air around us is a mixture of gases. Most of the air, about four-fifths, is nitrogen. About one-fifth is oxygen. Then there are small amounts of other gases like ammonia, argon, helium, krypton, xenon, neon and carbon dioxide. Finally, there is some water vapour in the air. Without oxygen we can not breathe, and without oxygen fires would not burn either—like us they would 'suffocate'. In about 1670 an English doctor John Mayow proved that fire consumes air. By repeating his experiment you can also see how a flame uses up a part of the air.



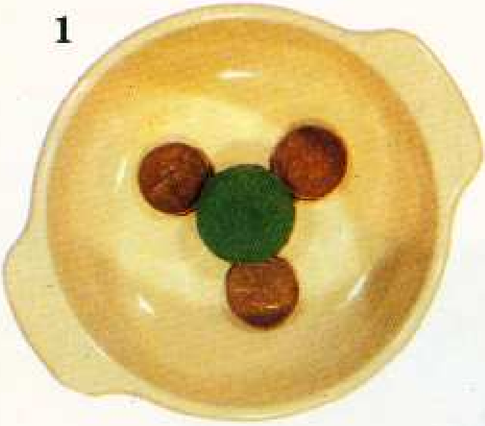
"Breathing" Fire

1. To test that fire actually consumes air, you need a few household items. Find a bowl made of something that is fire-proof, three conis, a clean glass jar, plasticine and a candle.

2. Push a small lump of plasticine in the middle of the bowl. Arrange the coins so that the top of the jar will rest on them without wobbling. Firmly push the candle into the plasticine and half fill the bowl with water.

3. Ask an adult to help you with this step. Light the candle and then very carefully lower the glass jar over the flame, resting it on the coins. Quickly mark the water level on the side of the jar. Watch the flame closely to see how it changes.

1



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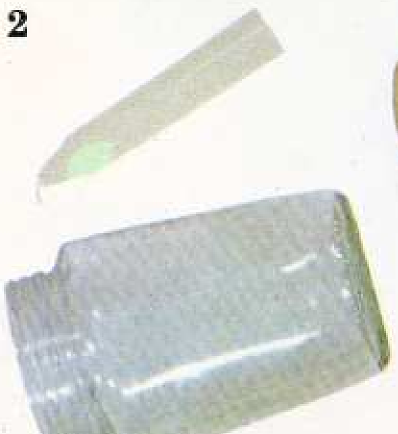
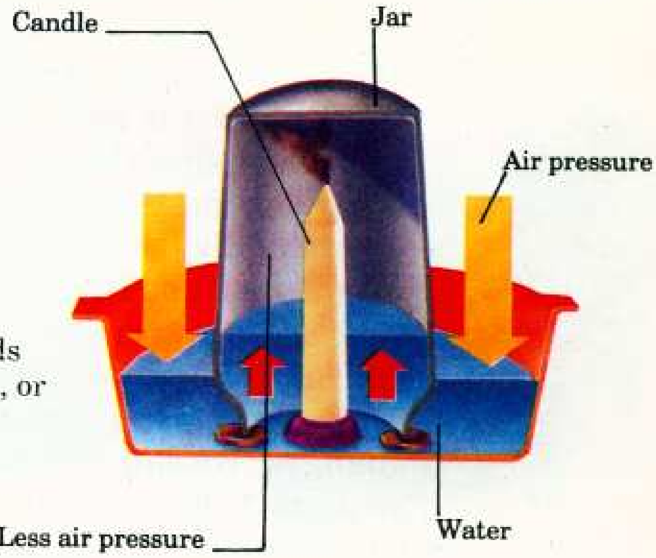


3

Why It Works

The flame consumes the oxygen in the air as it burns. Once the entire oxygen is consumed, there is no longer enough to support a flame and the candle goes out. Air pressure (see pages 8-9) pushes on the water from outside the jar. Inside the jar, the water is forced up and moves into the space left by the oxygen. The water level inside rises by about one-fifth, which is the fraction of oxygen in air. However, this experiment is not exact. Some of the air escapes from the jar as the flame burns because air expands when it is heated. As the air cools down, it shrinks, or contracts, making extra space for the water to fill.



4. Note what happens to the water at the bottom of the bowl. As the candle burns, do bubbles appear? When the candle goes out, does the water rise inside the jar? How high does it rise? Mark the side of the glass to show the new water level.

4

Bright Ideas

Light two candles. Cover one with a small jar and one with a large jar. Which candle burns the longest?

Place a dried pea into the neck of a bottle. Blow hard to make the pea go into the bottle. Is air pressure inside the bottle strong enough to keep the pea out?

Powerful Pressure

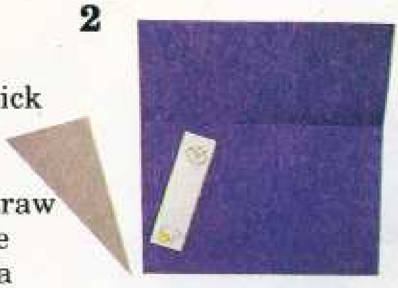
Air is all around us and is pressing on us all the time, although we don't really notice it much. Air pressure is caused because air has weight and it is pulled down to Earth by gravity. As it is pulled down it pushes things from all sides— this is air pressure. Our own blood pressure presses back against the air; if we suddenly take air pressure away, our bodies would explode. This is why space-men have to wear special pressurised suits: in space there is no air and so no air pressure. The changes in air pressure give us a clue about weather changes. We can measure air pressure and so predict the weather with an instrument called a barometer.

Weather Forecasting

1. You can make a simple barometer by collecting a new balloon, a clean glass jar, a straw, a toothpick, an elastic band and some thin card. Carefully cut the neck off the balloon. Stretch the balloon over the jar. Hold it in place with the elastic.

1

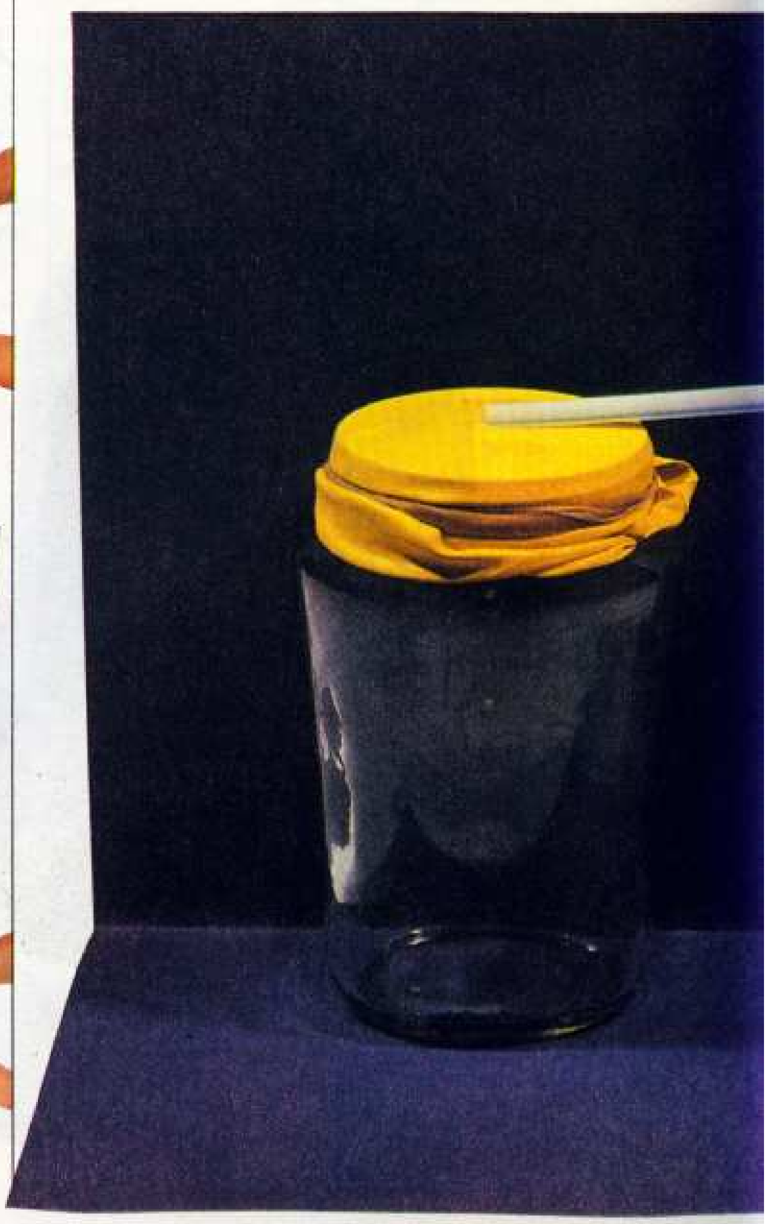
2



2. Tape the toothpick to the end of the straw. Tape the other end of the straw to the centre of the balloon lid. Make a weather picture chart with the good weather at the top.

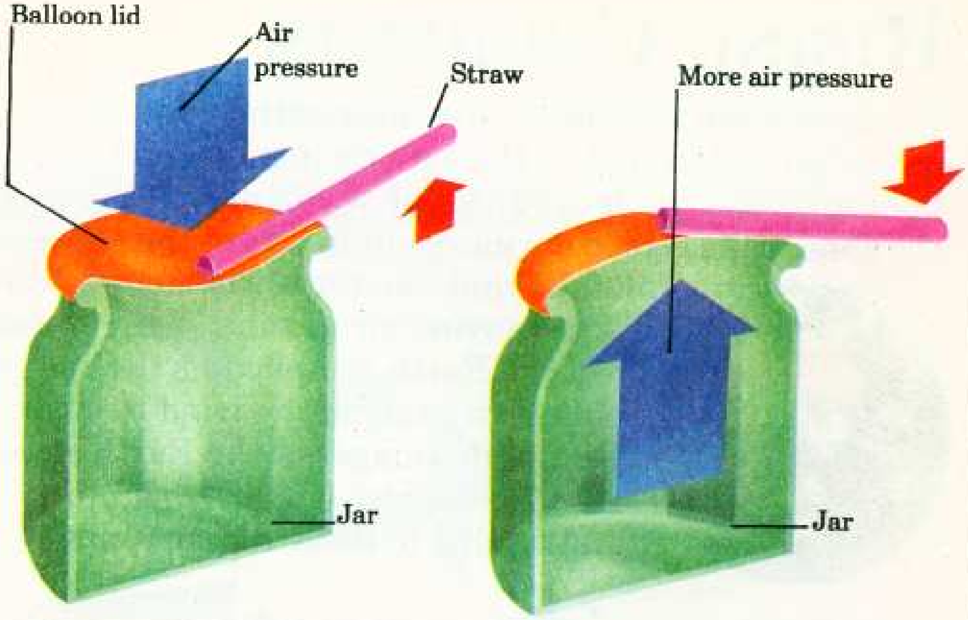
3

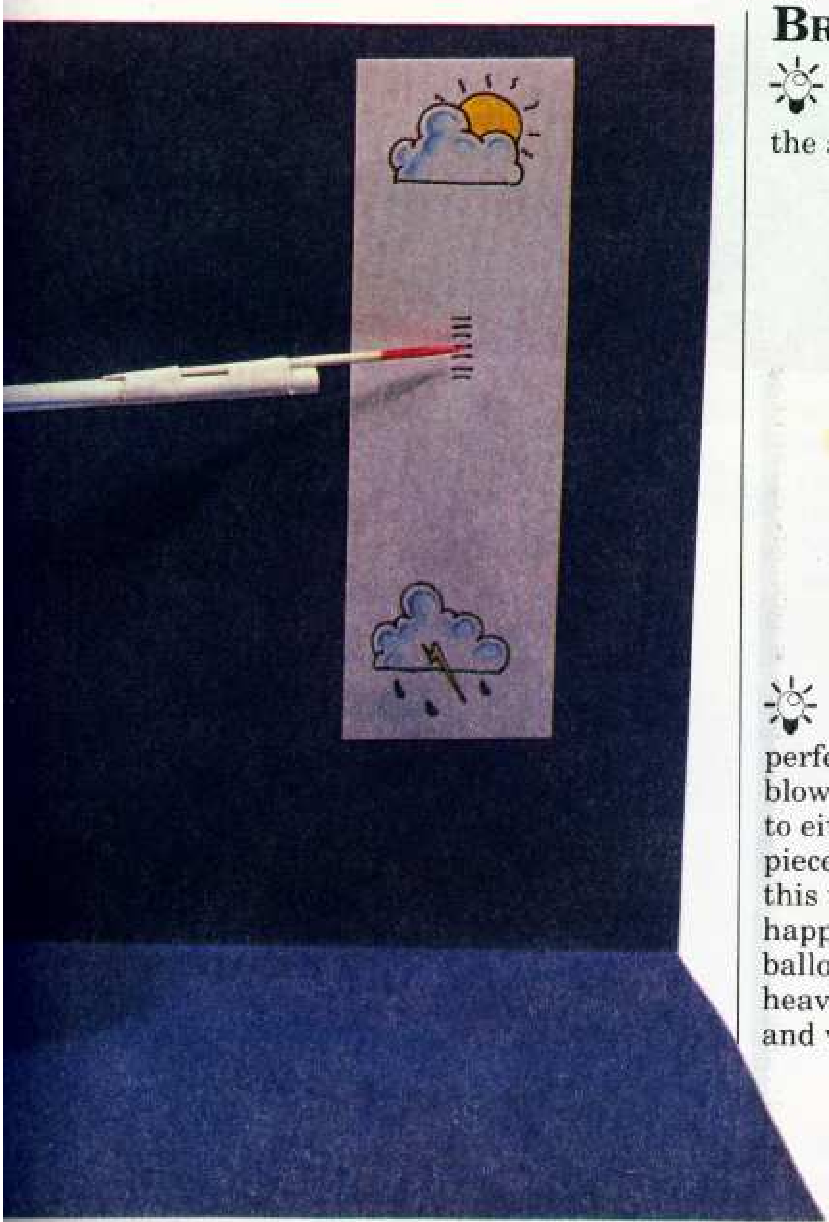
3. Fold the sheet of card and cut a card triangle for a support. Fix the weather chart in position. Put the barometer in place and watch the pointer move a little each day.



Why It Works

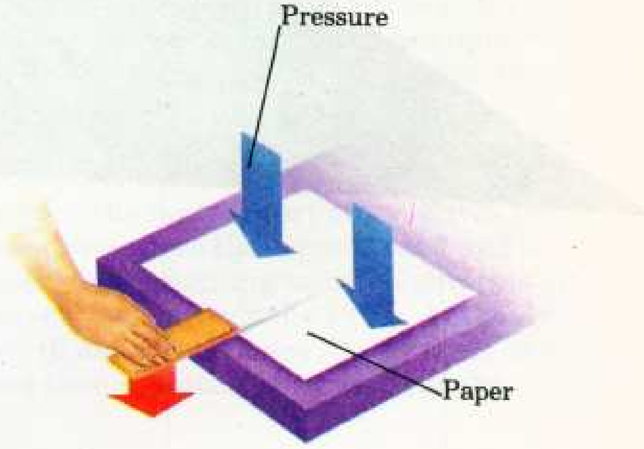
Air pressure changes all the time because of the endless movement of gas molecules. When the air pressure rises, indicating good weather, the pressure pushes down on your barometer's lid, making the straw pointer rise. When the air pressure drops, indicating bad weather, the lid swells and the pointer drops. Air temperature also affects pressure. Your barometer is most accurate when it is kept at a steady temperature.



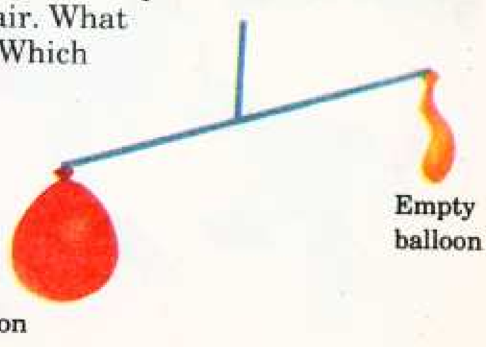


Bright Ideas

Try to lift a piece of paper from a tabletop using only a ruler as in the picture. Feel the air pressure try to stop you.



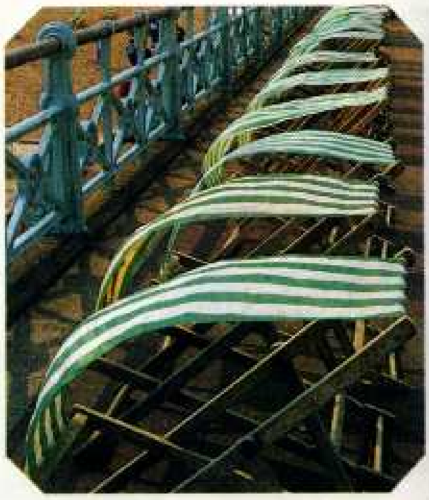
Very carefully hang a ruler from its centre by a string so that it balances perfectly. Take two identical balloons and blow one up. Stick the balloons with tapes to either end of the ruler. You'll need identical pieces of tape to keep this test fair. What happens? Which balloon is heavier and why?



RISING CURRENTS

Have you ever wondered what makes the wind blow? As the air is warmed by the sun it expands and becomes lighter. These changes cause the warm air to rise. At the same time cooler air moves in to fill up the space

left behind. So, the air is moving, and the moving air is wind. The rotation of the Earth complicates the pattern causing the wind to swirl. Satellite images of the Earth show the clouds above us in constant motion due to these air currents.

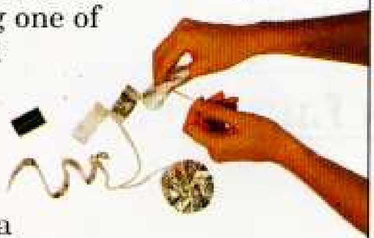


MOBILE AIR

1

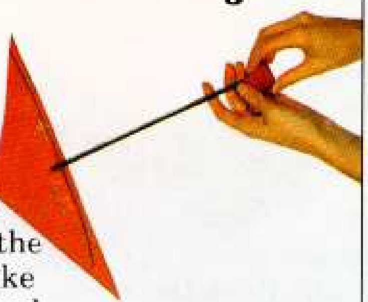
1. You can prove that hot air rises with a mobile that twirls in the slightest current. Cut some shapes from aluminium foil. For the mobile shown here you need two squares and two circles.

2



2. Turn one of the circles into a spiral like a snail's shell. Make a whirligig using one of the squares. Twist and cut the other two pieces, using your imagination, to make interesting shapes. With a needle, thread a length of cotton through each one.

3



3. Cut a triangle from a piece of card. Decorate one side and tape a stick securely to the other to make the stand. Fix a piece of plasticine to the bottom of the stick. Make sure that the entire stand balances upright evenly.

4

4. Carefully tape the cotton lengths to the back of the triangle. Make sure that each shape can twist freely. Place your mobile above a heater, keeping it well away from gas, fire and breezes. Watch the shapes twirl.

BRIGHT IDEAS

The spirals turn very nicely in the currents of rising hot air, but would other shapes turn as well? Try a twisted loop, a circle, a strip. Which works best? Are the best shapes similar to birds feathers or the wings of a glider? Do the spirals work better with longer or shorter strings? Is close to the heater best, or high above it?

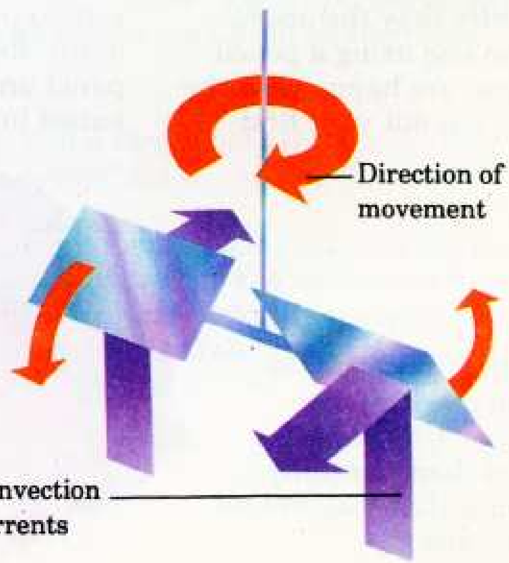
Twisted circle loop

Curved shape

WHY IT WORKS

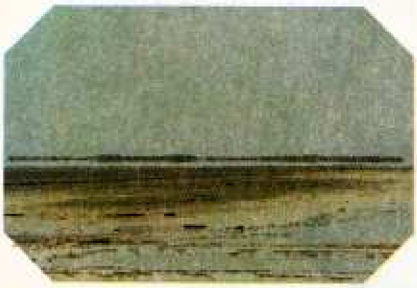
Your mobile shapes dangle at rest when placed elsewhere in a room, but they would twirl when hung above a heater. This is because rising warm air pushes upwards on the edges of the shapes, causing them to twist and turn like a propeller.

The movements of hot and cold air are called convection currents and cause many winds. The hottest part of the Earth is the equator — here the air is heated and it rises. After reaching some height, this air travels out towards the Poles. At the cold North and South Poles the air cools and falls, and then it travels back towards the equator.



Hot Air Flight

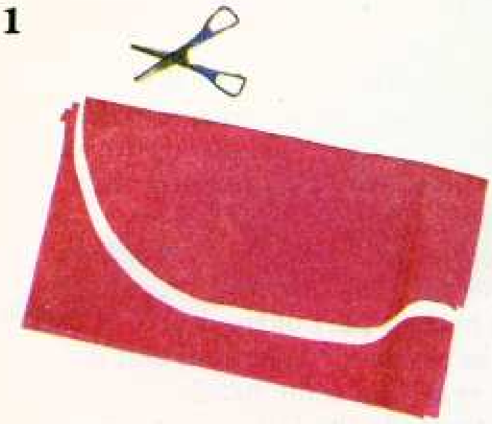
Have you seen a hot air balloon? More than 200 years ago, two French brothers, Joseph and Jacques Montgolfier, discovered that rising hot air could be trapped and used for flight. They made a huge balloon from linen and paper and lit a fire underneath it. The balloon trapped the hot air and smoke



rising from the fire and lifted the two men into the air. As the air cooled, the balloon floated back down to the ground. Since that first flight, people have used hot air balloons for pleasure, for racing and even for warfare. You can make your own hot air balloon.

Balloon Lift-off

1



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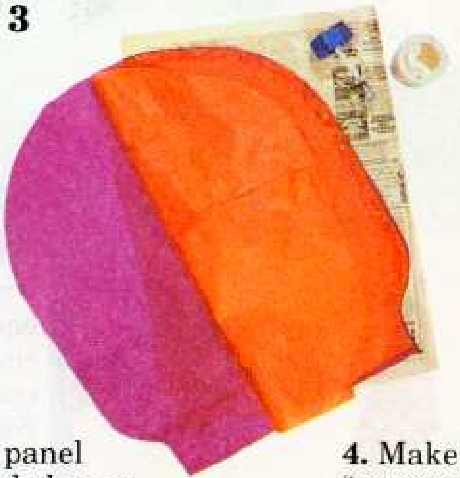


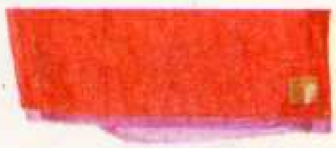
1. To make a balloon that traps hot air to fly, you need four large sheets of tissue paper. Fold each sheet in half and lightly copy the above shape on one using a pencil. When you are happy with the outline, cut out your first "panel".

3. Unfold your first panel and spread glue on the edge of one half. Stick the second panel on top and press down. Repeat with the next panel until all four panels are joined into a balloon.

4. Make a small "passenger basket" from a piece of folded card. Attach the basket to the open end of the balloon with four lengths of cotton.

2

2. Use the first panel to help you mark out the next three. Cut them out and trim them carefully. Make sure that they are all the same size.

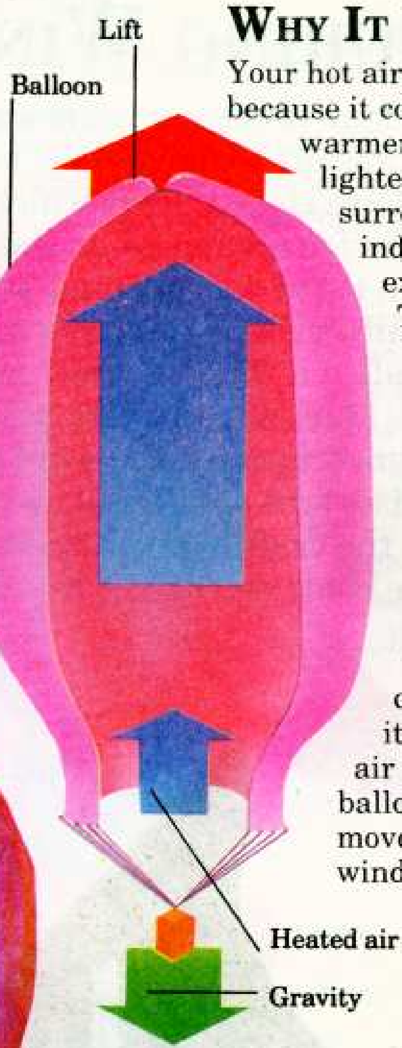


4

5. Take the balloon outside for your first flight. Blow the balloon up with hot air from a hair dryer and watch it lift off.

5

Why It Works



Your hot air balloon rises because it contains air that is warmer — and therefore lighter — than the surrounding air. (Air, indeed all gases, expand when heated. They become lighter because the same amount of gas takes up more space.) Hot air from the dryer enters the bottom of the balloon and rises inside to the top, causing the balloon to lift off. The colder the air around it, the faster the hot air will rise. A hot air balloon has no power to move along — it needs a wind to help it.

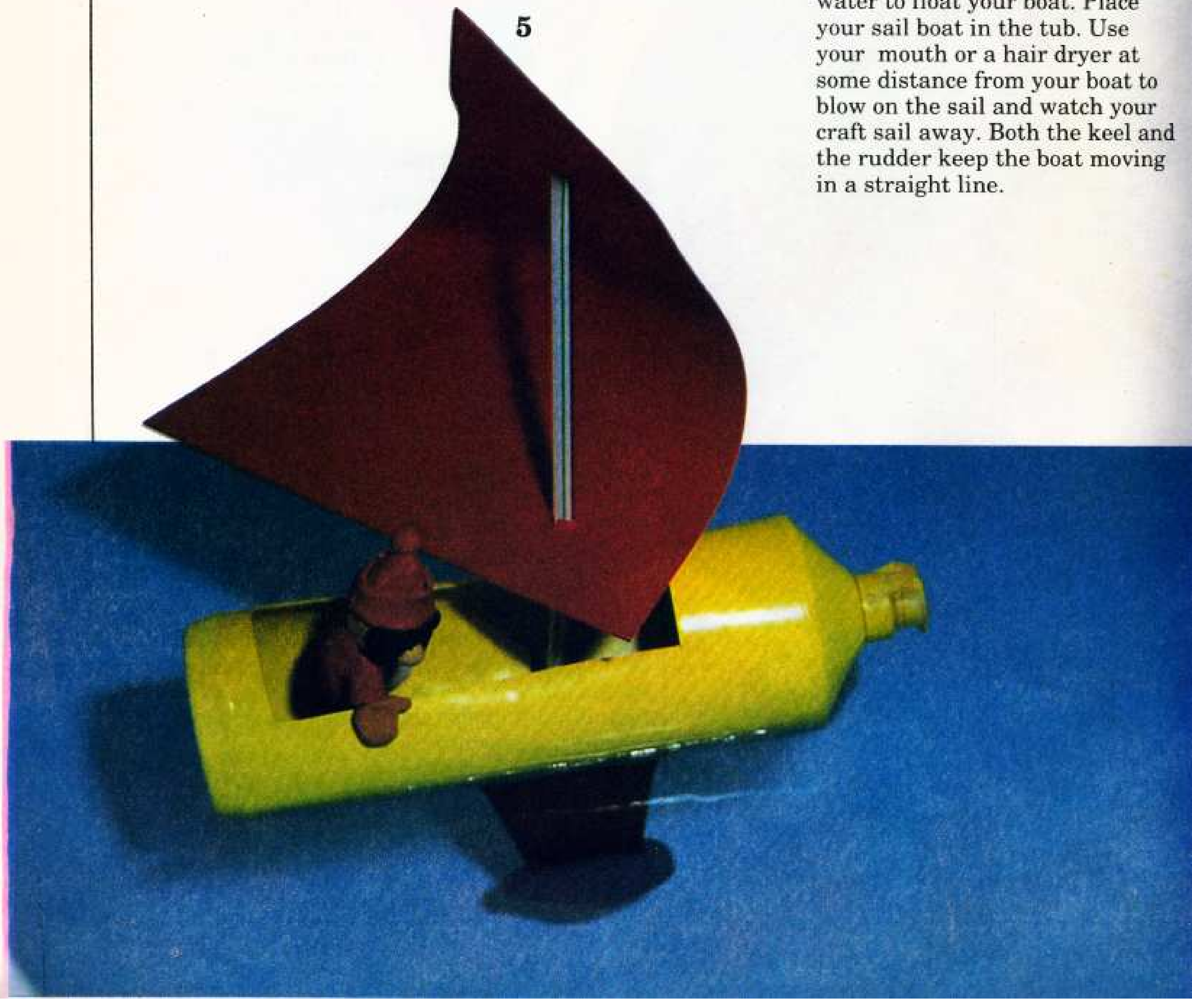
Bright Ideas

- Will your hot air balloon work better in a hot room or a cold room? (See **Why It Works**, above.)
- Make some plasticine passengers for your basket. Does the balloon need more hot air for lifting power?
- Will a larger hot air balloon rise even better? Make one and find out.
- Watch the smoke rising above a bonfire. Do you see how the hot air carries it up? As the air cools the smoke stops rising as fast. What happens then? Does the smoke scatter in the wind?

Capturing Wind

More than four thousand years ago, people were already capturing the wind in sails to move their boats through water. These boats had "square rigged" sails which caught the wind. But they used oars for rowing when the wind blew the wrong way or when there was no wind at all. About 1,500 years ago, sailors discovered that with a special triangular sail called a "lateen", they could sail even against the wind. Modern sail boats have tough, nylon sails designed to catch the wind from any angle. A windsurfer's single sail swivels around the board to take the craft in any direction. By trying it out on a simple boat, we can see how a lateen sail works.

5



5. Fill the bath tub with enough water to float your boat. Place your sail boat in the tub. Use your mouth or a hair dryer at some distance from your boat to blow on the sail and watch your craft sail away. Both the keel and the rudder keep the boat moving in a straight line.

Sail Power

1. To make a sail boat, first cut a rectangular hole in the side of a plastic bottle.

1

2. Fix a piece of plasticine inside the bottle boat. Use it to hold your straw mast in place.

2

3. Cut a triangle from a piece of paper and decorate it if you wish. Pierce two holes through your sail. Insert the mast through the holes.

3

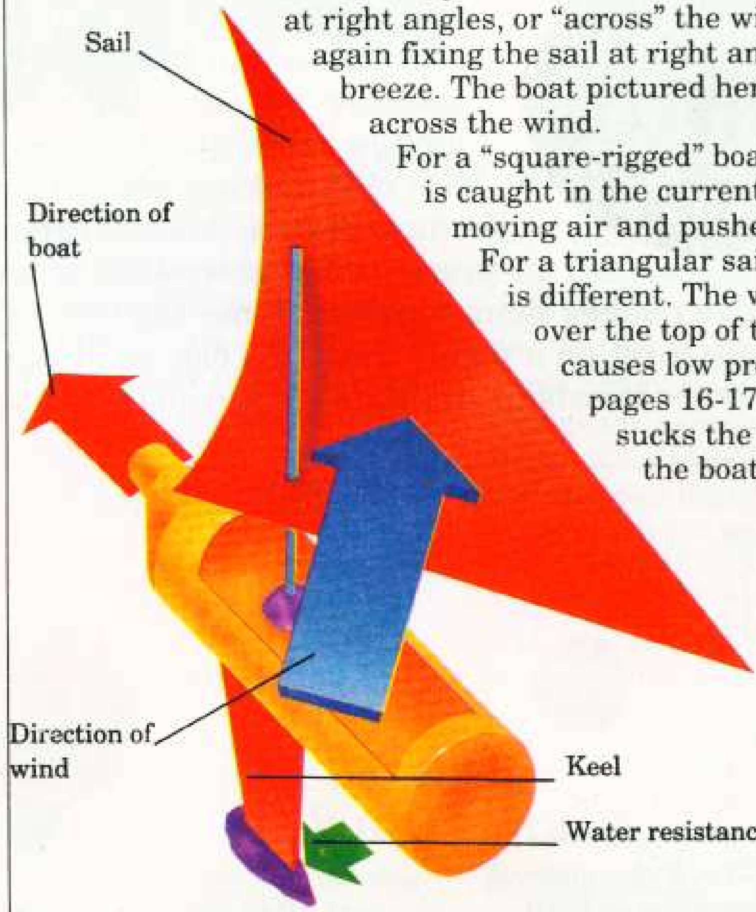
4. Cut a wedge shape from cardboard carton for your waterproof keel. Put a chunk of plasticine on each end and attach it to the boat.

4

Why It Works

No matter which way you blow on it, your sail boat can be made to go in any direction. When the wind is directly behind the boat and you hold the sail at right angles, the wind moves, your boat forward. You can move at right angles, or "across" the wind by again fixing the sail at right angles to the breeze. The boat pictured here is sailing across the wind.

For a "square-rigged" boat, the sail is caught in the currents of moving air and pushed along. For a triangular sail the effect is different. The wind blows over the top of the sail and causes low pressure (see pages 16-17) which sucks the sail, and the boat, forward.

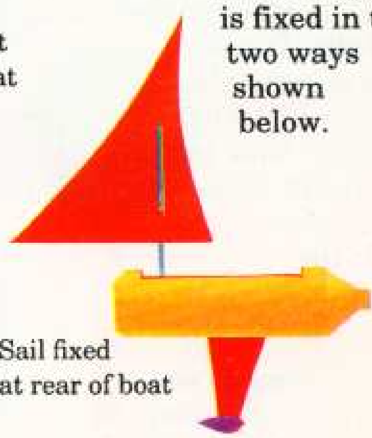


Bright Ideas

Which shape do you think is the best for a sail? Experiment with squares, rectangles, circles and triangles. Once you've found the best shape, try it out in different sizes. Find out if a smaller sail or a larger sail is better.

Blow on your boat from different directions. Watch how the boat moves every time. Now, keeping the "wind" blowing from one direction, see what happens when the sail is fixed in the two ways shown below.

Sail fixed at front of boat



Sail fixed at rear of boat

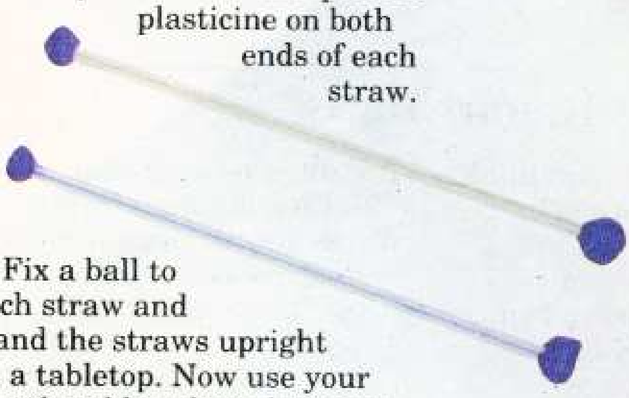
Pressure Changes

Even though the rush of wind blows things about, moving air has lower pressure than still air. This is because air molecules have a set amount of energy. When air blows slowly, it has some energy left to create sizeable pressure. But when air moves quickly, this motion takes up a lot of energy. Therefore, less energy goes into making pressure and the air pressure drops. Because of this, when air moves between things the air pressure between them is low and the higher pressure on other sides pushes them together. Even the tops of tall buildings bow together a little bit on a windy day. This can be illustrated in the project below using simple materials to simulate skyscrapers on a windy day.

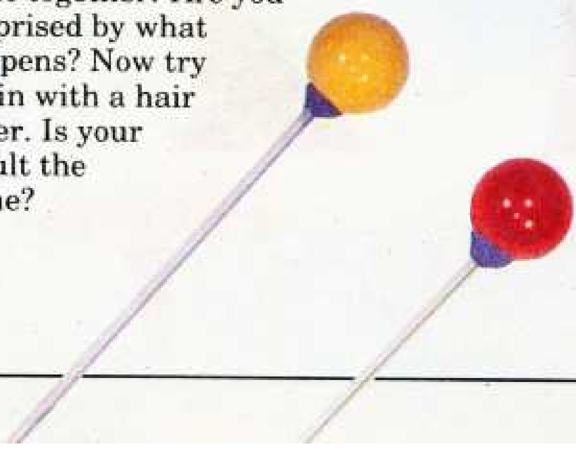
Blowing Balls

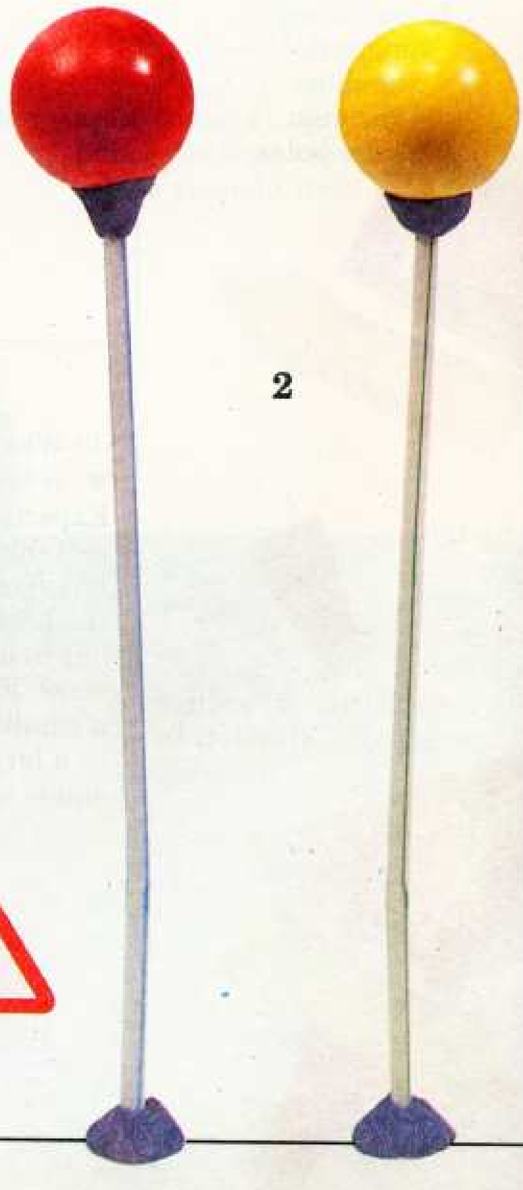
1. You can prove that air pressure drops when air moves and this causes objects to bend together. Find two light plastic balls; table-tennis balls are just right. Collect two straws and some plasticine. Put a piece of plasticine on both ends of each straw.

1



2. Fix a ball to each straw and stand the straws upright on a tabletop. Now use your mouth to blow down between the balls. Do they go apart or come together? Are you surprised by what happens? Now try again with a hair dryer. Is your result the same?

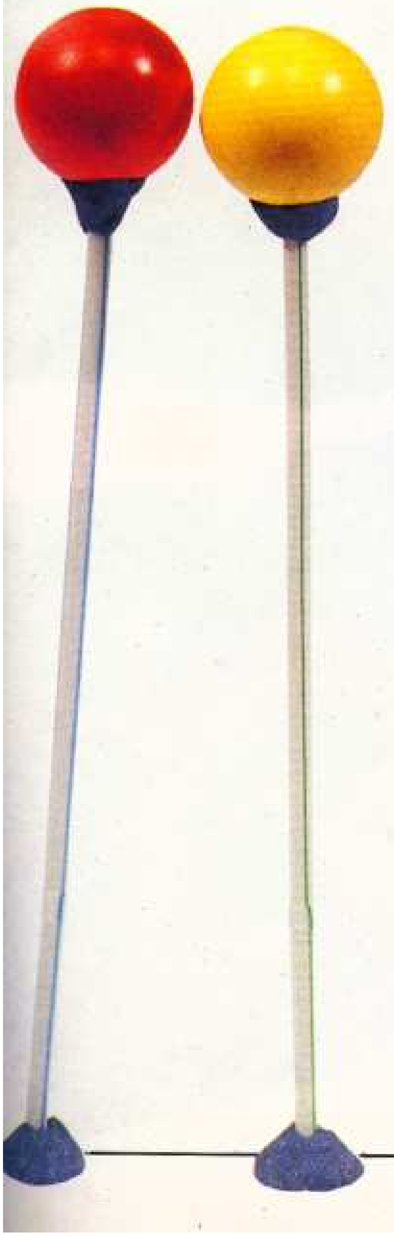




2

BRIGHT IDEAS

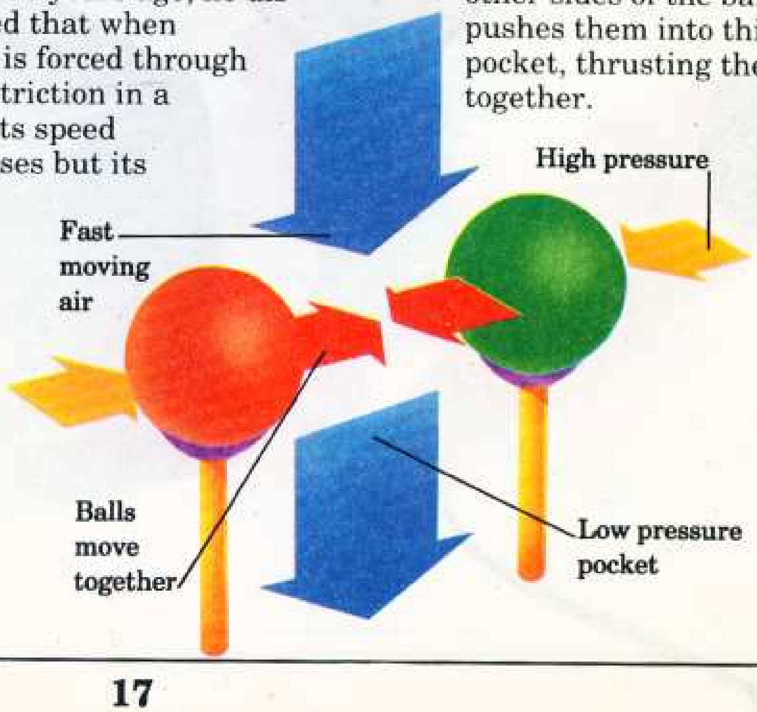
- Blow the air onto the standing table tennis balls from different directions. Are the balls still drawn together if the air hits them from the side or from below?
- Hold two strips of paper about 5cm apart and blow between them. See how the fast moving air pulls the strips inwards.
- Hold a sheet of paper loosely in front of your mouth and blow over the top. Does the paper rise?
- Cut two small flaps in the end of the strip. Bend one flap down. Blow over the paper again. How do the flaps change the paper's motion? Rest a piece of paper over a gap between two books. Blow underneath the paper and watch where it goes.
- Place a small cardboard disk on a table and see if you can lift it simply by blowing over the top.



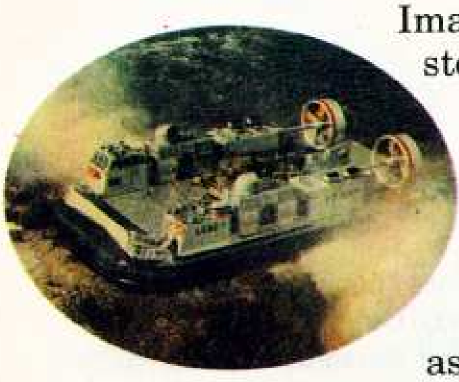
WHY IT WORKS

When you direct fast moving air between the balls, they do not move apart but come together. This is known as the "Bernoulli effect", named after the Swiss mathematician David Bernoulli. More than 250 years ago, he discovered that when water is forced through a constriction in a pipe, its speed increases but its pressure drops.

Fast moving air too has low pressure. As you squeeze fast moving air past the two balls, it makes a low pressure pocket between them. The "high pressure" air on other sides of the balls pushes them into this pocket, thrusting them together.



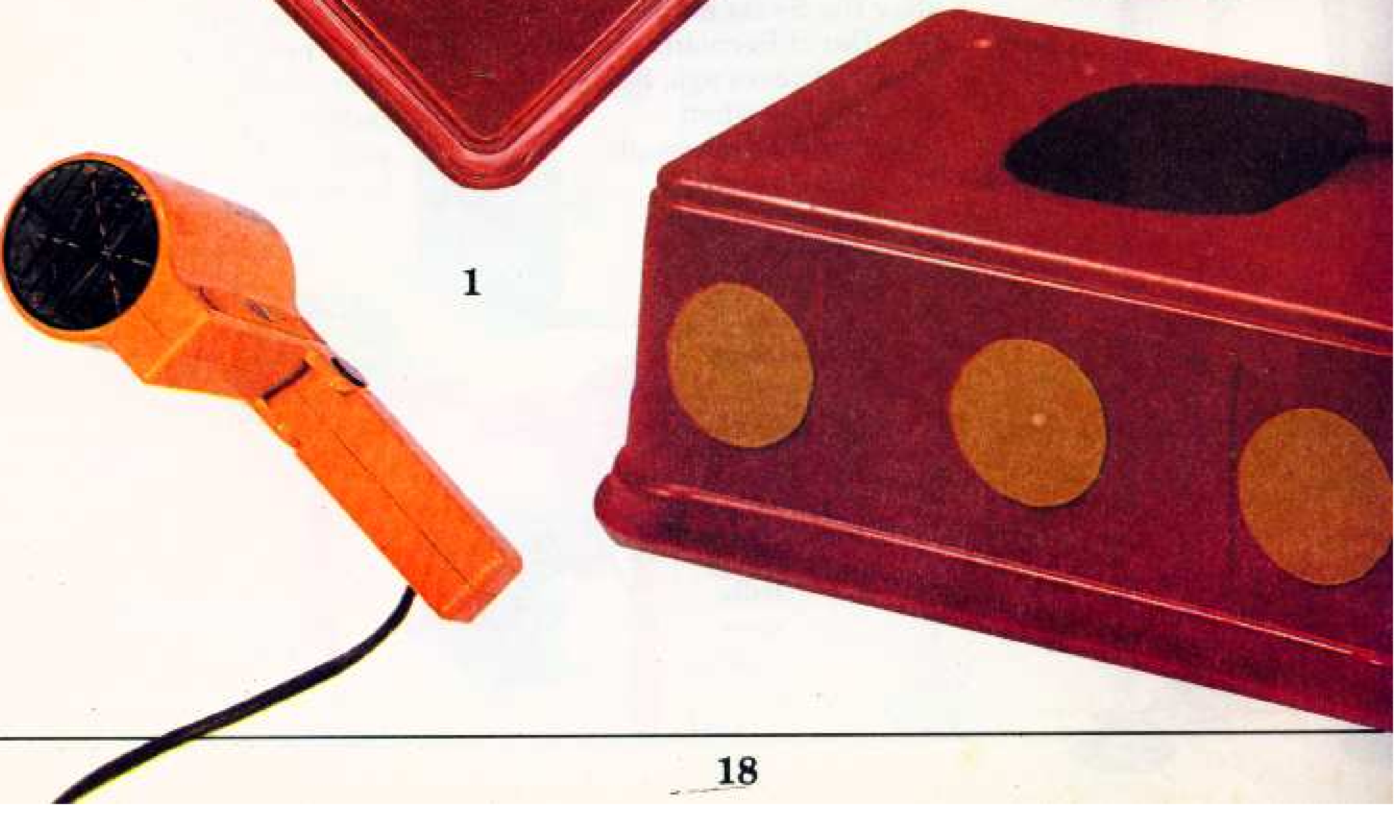
Air Cushion



Imagine you are riding your bicycle on a level road and you stop pedalling. What happens? You move a little further but eventually you slow down and stop. This is because the tyres rub against the road causing friction. At one point of time the force of friction is so strong that it makes the tyres stop turning. On a very rough road you would stop more quickly because rough surfaces cause more friction than smooth ones. Air can be used as a cushion to cut down on friction, allowing vehicles to ride almost effortlessly. For example, a hovercraft floats smoothly on air without dragging on the surface of the water or rubbing on the ground as it moves along.

Speedy Hovercraft

1. With this simple model you can see a hovercraft in action. Find a clean plastic container. (A small rectangular lunch box is ideal. Heavier boxes do not work as well.) Ask for help to cut a hole in the middle of the base. Decorate the hovercraft as you wish.

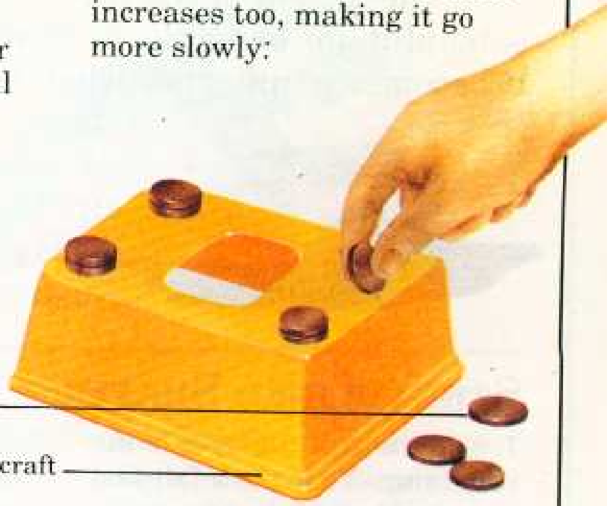


1

2. Put your hovercraft on a smooth surface with the hole at the top. Blow into the hole with a hair dryer and watch how it floats on a cushion of air. Tap it and see how easy it is to set it moving. Now turn the dryer off and tap it again. Does it move as easily?

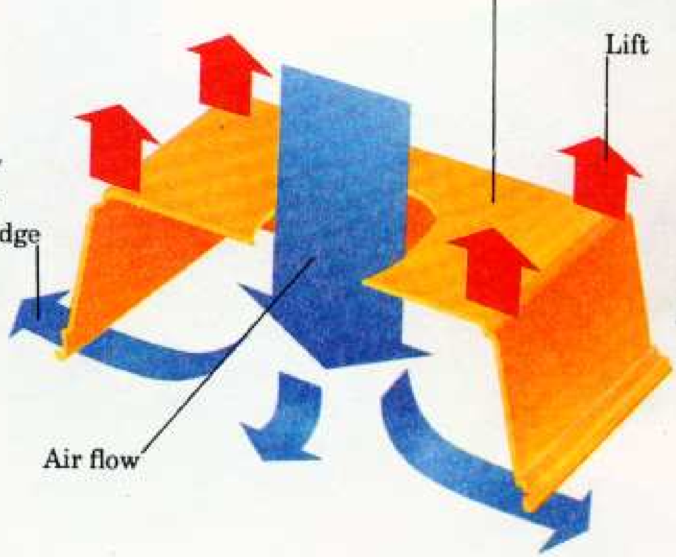
Bright Ideas

Let's investigate air cushions. Rub you hand very quickly backwards and forwards on a table. Did your hand get hot? This heat is caused by the force of friction. Rub your finger on a dry part of the sink. Does it move easily? Now rub soap on your finger and try again. You will feel the soap acting as a lubricant and reducing friction. Air too acts as a lubricant. The smaller the amount of air separating the hovercraft from the surface beneath it, and the slower the air moves, the more friction on your craft. Watch what happens when you use coins to weigh down each corner. Try blowing on your hovercraft now. Does it work as well? When the weight of a vehicle increases, the friction increases too, making it go more slowly.



Why It Works

The force from the jet of the dryer pushes under the rim of your hovercraft causing it to rise gently. Held by a cushion of air, the hovercraft does not push down heavily on the floor or tabletop, and it can glide freely. Friction due to a solid surface, which slows things down, is absent here and hence it cannot halt the movement of a hovercraft. The air cushion creates a "frictionless surface" beneath the craft allowing it to move freely about.



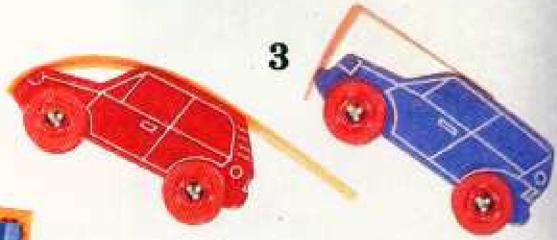
Air Resistance

If you open an umbrella and try to run with it on a calm day, you will find it difficult. The umbrella captures the air like a parachute and drags you back. Whenever we move, we experience air resistance and we have to push the air out of the way. Sometimes air resistance is helpful, for example, in slowing down a parachute. It becomes a nuisance when it acts against a sports car. Some shapes are "streamlined" to make them move smoothly through the air. They experience less air resistance because the air does not rub too much against them and block their movement.

Streamlined Shapes

1. You can test the force of air resistance. To make a fair test, you need two of the same model cars. Make sure their wheels turn freely.

2. Cut out two rectangles from the same piece of card. Again, to keep the test fair, make them the same size and shape.



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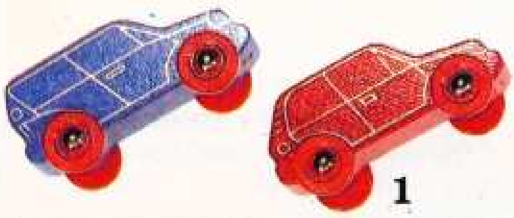
3. Fix the rectangular card to the front end of each car. Fold one smoothly over the top and bend the other one as shown. Tape the cards in place.



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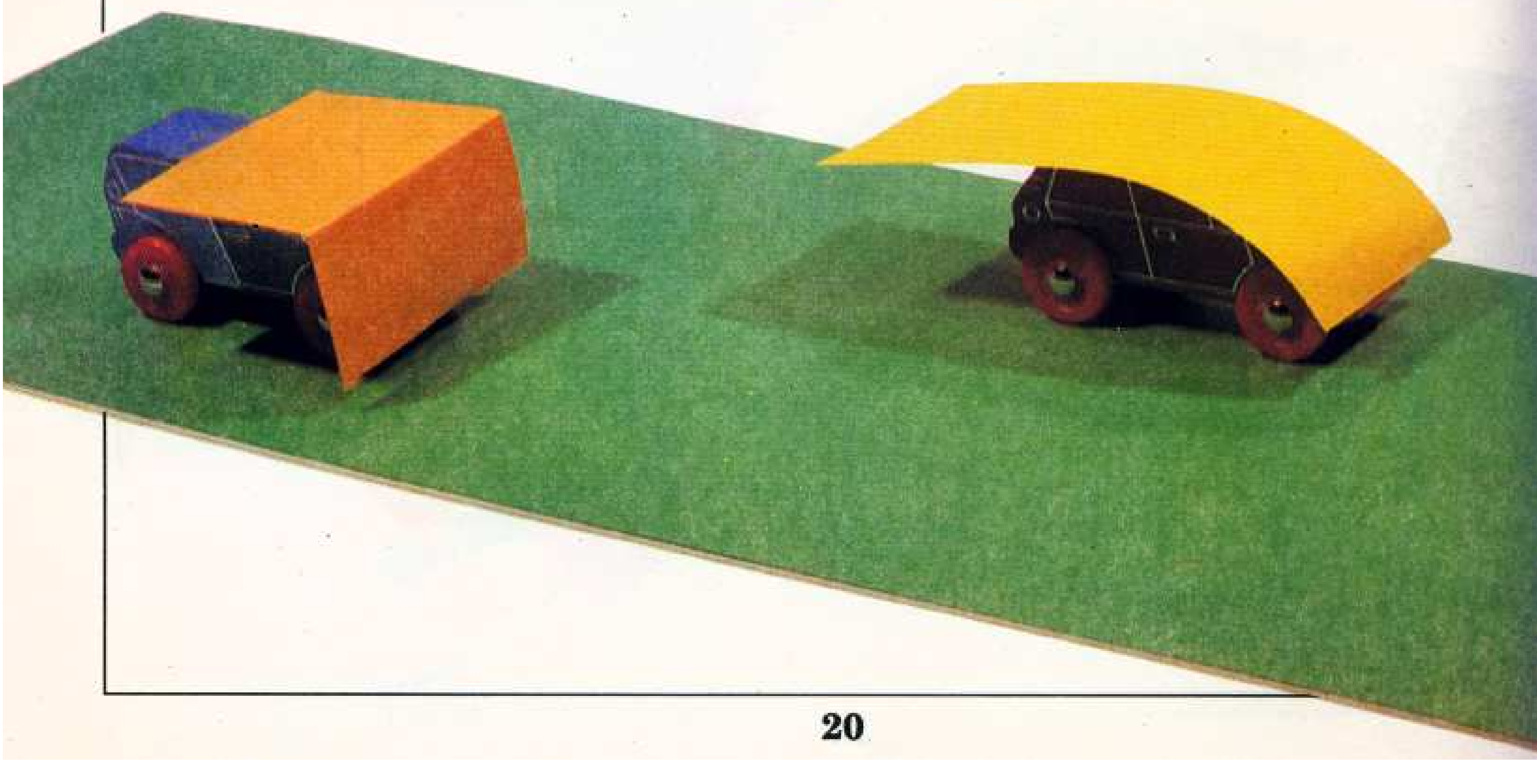
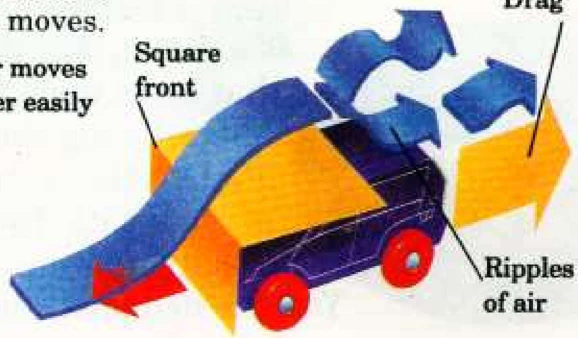


Why It Works

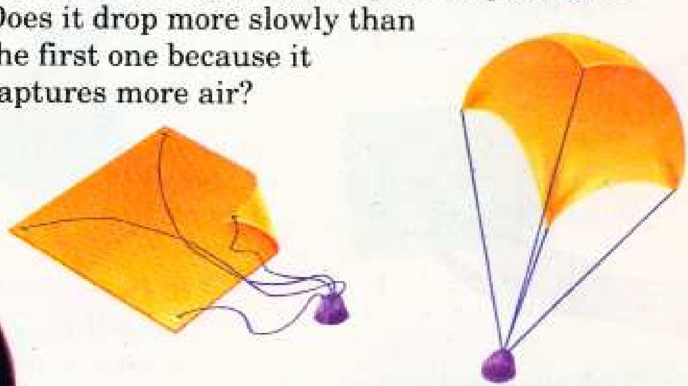
The shape of your cars makes them roll quickly or slowly. Air flows smoothly over the car with the rounded paper front. This streamlining allows it to roll faster than the car with the square front which is held back by air resistance or drag. Drag slows things down, creating ripples of air behind them. These moving ripples, called eddies, lower the air pressure behind the unstreamlined car, keeping it back as it moves.

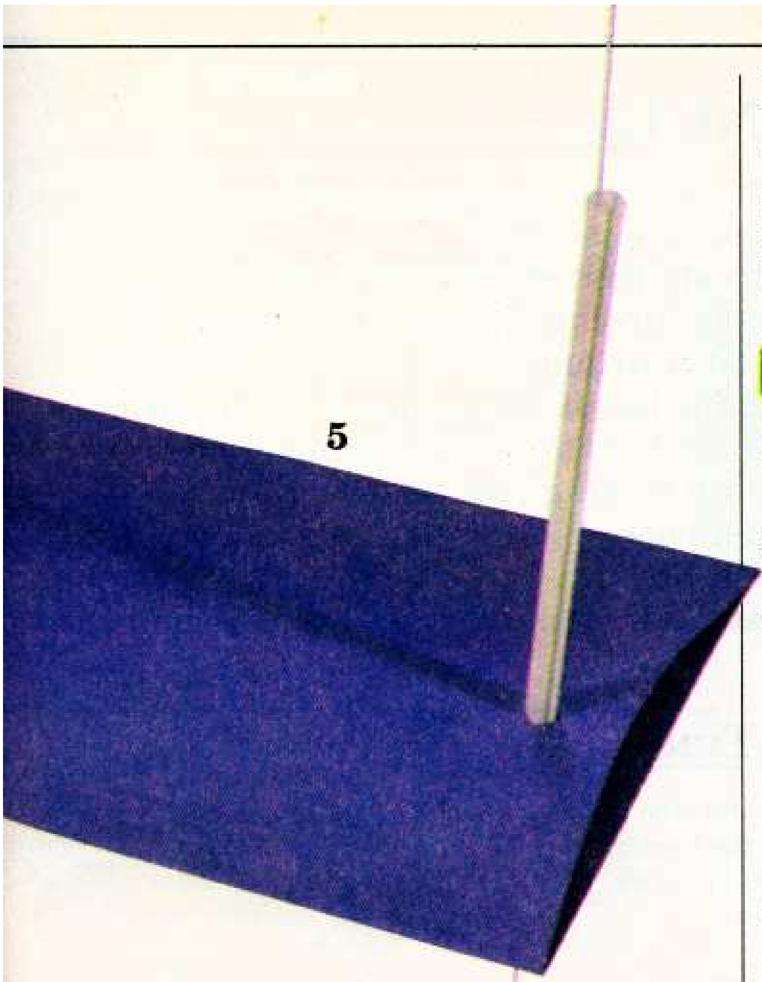


4. Tilt a board on a book to form a ramp. Release the cars at the same time from the top of the ramp into a wind from a hair dryer. Which one experiences least air resistance?

Bright Ideas

Capture air with a simple parachute. Tie four strings to the corners of a large handkerchief. Fix a peice of plasticine to the strings. Now make a larger parachute from paper, attaching the same piece of plasticine? Does it drop more slowly than the first one because it captures more air?

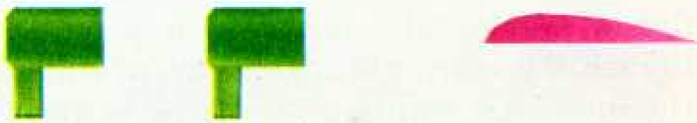




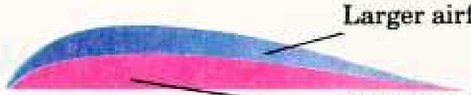
5. Thread a long piece of cotton through each straw. Pull these tracks tight and fix them straight between a floor and table, so that the wing can slide up and down freely. Lift the wing up a little and aim a hair dryer at the folded edge. Turn the dryer on, and watch your wing soar. Make sure that you are pointing the dryer straight for the best lift.

Bright Ideas

Turn your aerofoil upside down and test it again. What happens now? Move the hair dryer back from your aerofoil. Does it stay up? How far back can you move the hair dryer before the aerofoil drops down?

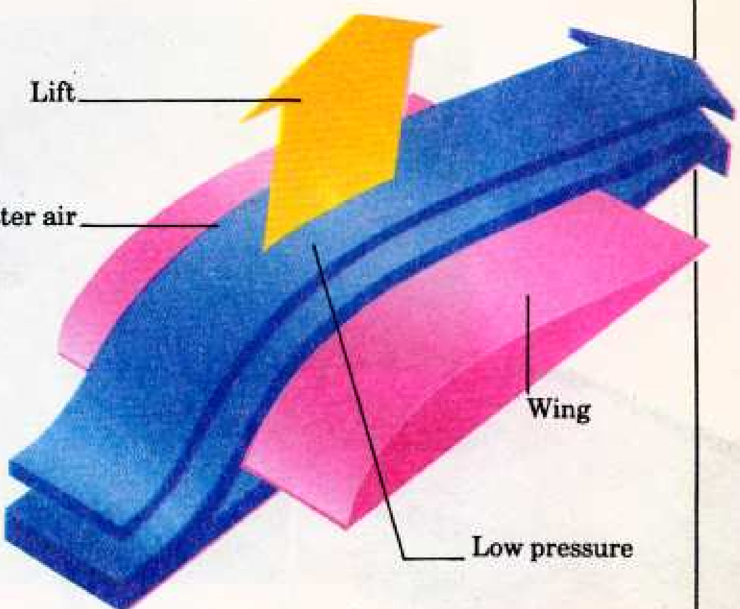


Make another aerofoil double the size. It creates lower pressure above. Can you move the hair dryer even further away?



Why It Works

Your aerofoil rises because of its shape. The top surface of the wing is longer than the bottom surface. Air passing over the top of the wing has farther to travel — so it has to go faster. Faster moving air has lower pressure. (Remember the Bernoulli effect!) Low pressure above the wing causes it to lift.



Airstream Evidence

Some things are shaped to move through the air very smoothly, such as rockets, aeroplanes and racing cars. Can you think of any more?

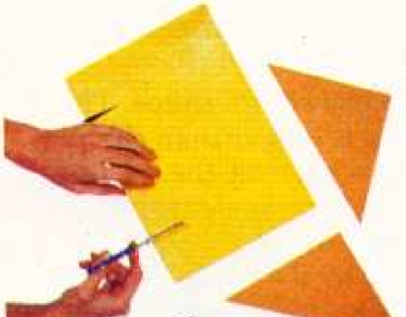
Designers use a wind tunnel to test streamlined shapes. Streams of smoke are blown over new models to show how air currents move around them. The flow of smoke tells designers how much air resistance their vehicles will have to face. The straighter the flow of smoke, the less it curls when it hits a surface, the more streamlined the shape is and the better it will move through the air.

Fast moving shapes are also slowed down by drag. The faster a car or an aircraft moves, the more that drag holds it back. A low drag shape in a wind tunnel will have straight smoke streams behind it.

You can use a hair dryer and ribbon instead of smoke to study how streamlined different shapes are.

Wind Tunnel

1. Make a backdrop for watching airstreams.



1

2. Cut slits in the side of a cereal box for the backdrop. Push two card triangles through the slits.

2

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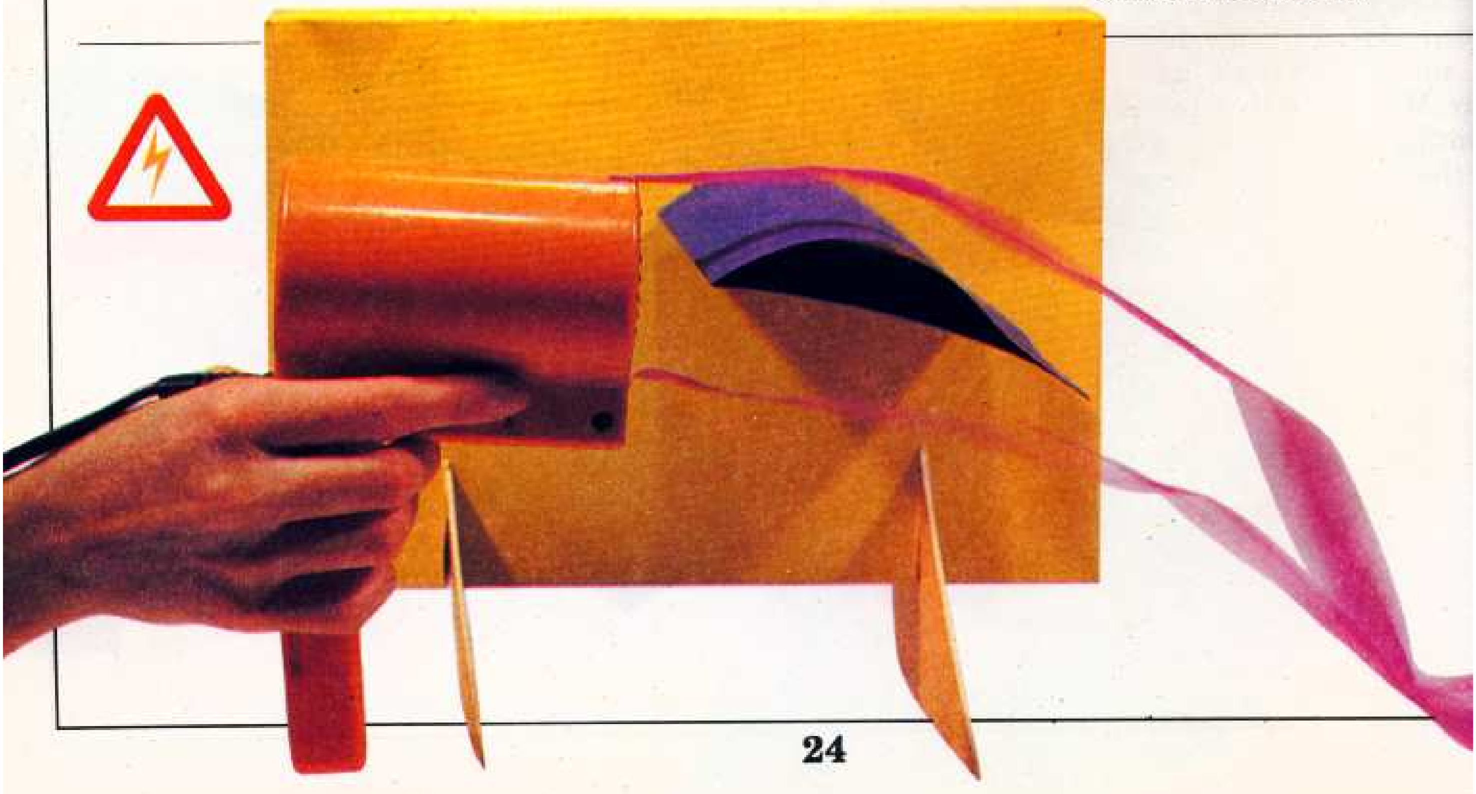
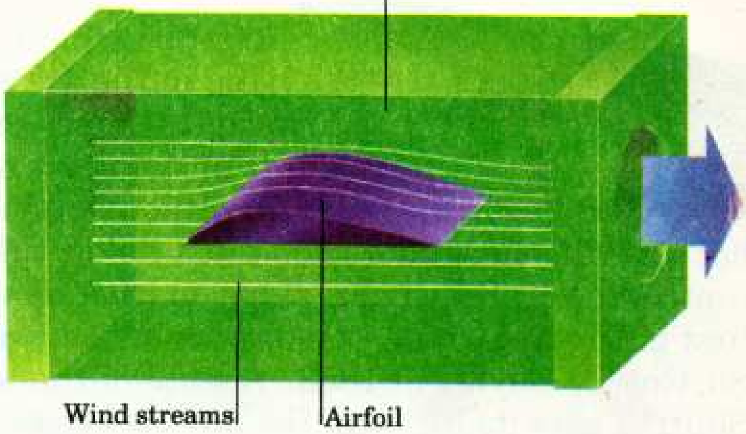
3. Carefully make holes through the centre of the box and push two thin sticks through them. (Thes sticks will support shapes for testing, such as your aerofoil and a ball.)



Why It Works

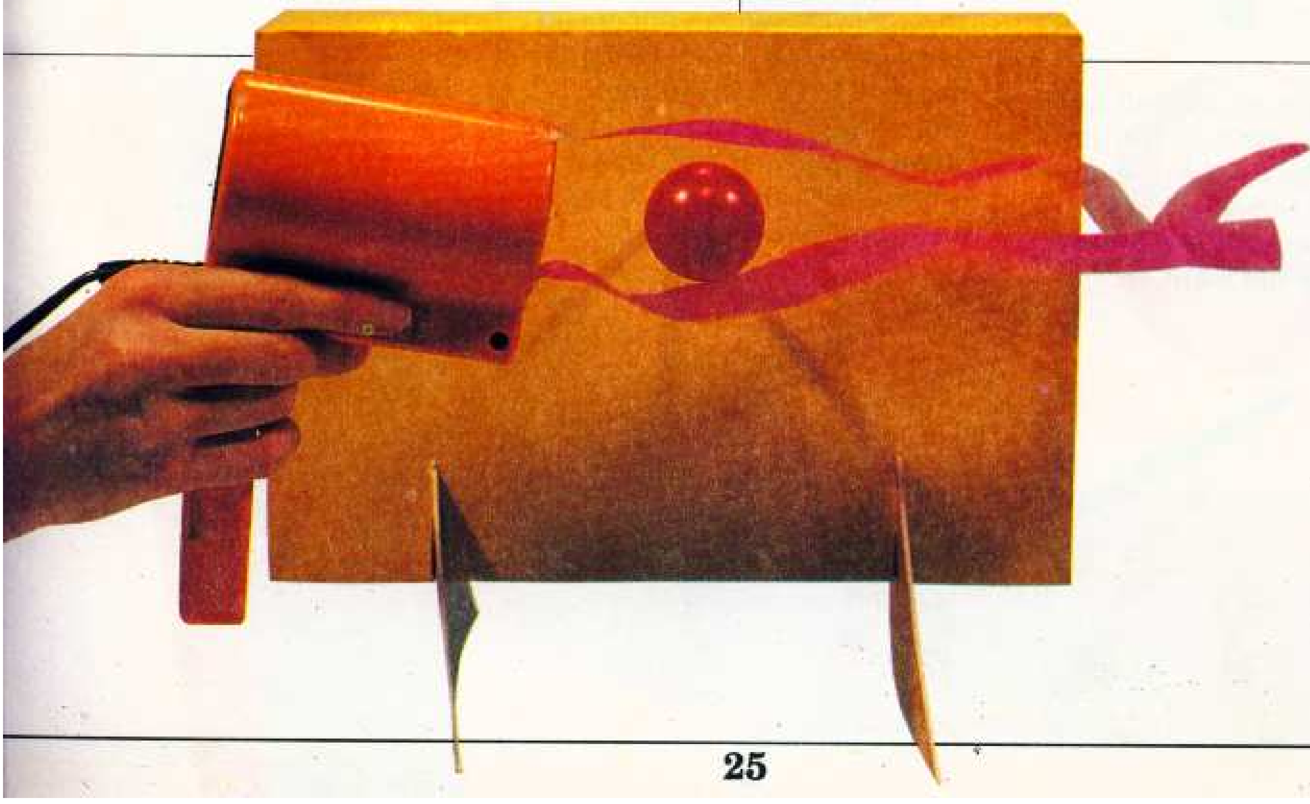
Your aerofoil does not disrupt the lines of smoke — or the ribbons — as they pass over its surface. Instead, the smoke streams continue in almost the same lines as before they struck the wing. This means that the wing can move freely through the air. Air does not rub against it too much and therefore it is not down by air resistance. (Like water in a swimming pool that seems to push us back if we walk through it, air resistance is a powerful force.)



4. Fix two thin ribbons onto a hair dryer. With the dryer sets on "cool", watch how the ribbons blow over your shapes and see the airstreams around them.

Bright Ideas

See how streams of air move around two different cars. Fix paper fronts on toy cars as shown below (see pages 20-21). Stand each car above a tabletop on a stick of plasticine. Test each for streamlining.



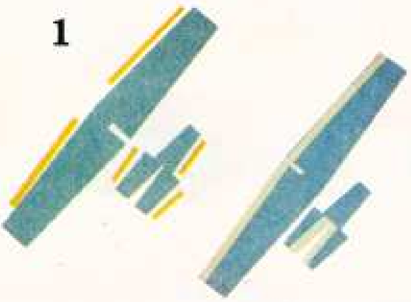
Glider Flight

Have you seen a buzzard, a gull or a kestrel in flight? At times some birds seem to hang in the air without at all flapping their wings. Gliders copy these birds, floating on currents of rising air called thermals. Like kites, gliders fly without engine power. However, unlike hot air balloons, gliders don't just follow the wind. A glider pilot can control the craft by using flaps on the tail and on the wings. The first glider to carry a person was built by an Englishman called Sir George Cayley in 1853. A state-of-the-art glider, the Space Shuttle, gets its lift from the airflow around it. You can make your own simple glider in the project below.

Aircraft Design

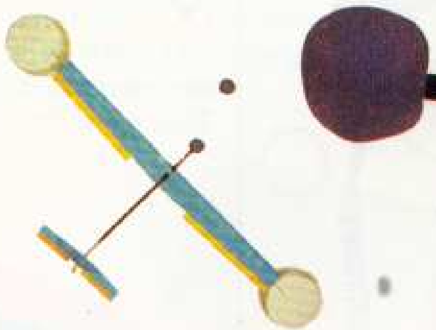
1. Study the pictures before you begin. The yellow strips show the flaps and the rudder. The white strips are for double-sided sticky tape.

1

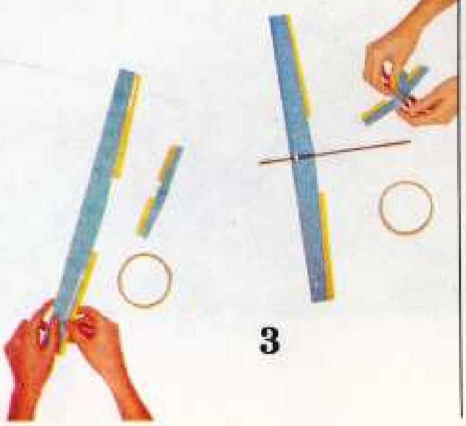


2. Make the wings and tail from light, strong, thin card. Cut out the two blue shapes and the five yellow flaps. Your glider can be whatever size you want.

2



3. Tape on the yellow flaps. Feed a drinking straw through the wings to make an aerofoil shape. Use a knitting needle for the body of the glider. Split a 4cm piece of straw at one end and tape it around the tail and onto the knitting needle.



3

Bright Ideas

Make your glider "roll". The wings give the glider stability — by moving the wing flaps you can shift its balance.

You can make your glider climb and dive by moving the flaps on the tail planes.

A pilot controls the "yaw" with the rudder on the tail. For a yaw to port (a turn to the left), set the rudder as in the picture below. Now try a yaw to starboard (a turn to the right) with your own rudder set as in the picture below.

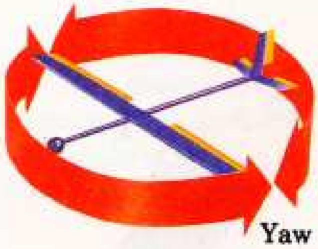
Roll Pitch Yaw

4. To test the glider's balance, rest it on two cups and toothpicks. Adjust the plasticine nose until the balance is even. Now you are ready to take off. Find an open space and a calm day for your first flight.

Why It Works

Wings and tail flaps help steer your aircraft. Depending on how these flaps are set (see **Bright Ideas**), your craft rolls, turns, climbs or dives as shown below. This is because the forward motion of the plane is redirected by the force of air hitting the tilted flaps.

Roll



Yaw

Pitch

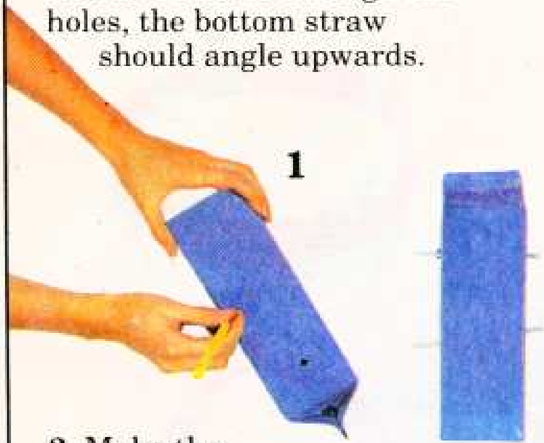
PROPELLERS AND FANS

Have you ever heard a news report about a hurricane? The power of the wind can be very dangerous, destroying buildings and uprooting trees. If we can capture the wind, it can be helpful, too. Once, windmills used the wind's energy to drive grinding and threshing machines. Today smaller, modern windmills make electricity or pump water. The blades of a windmill use the same principle as aeroplane do, where the special shape of the wing makes them move smoothly in the air. Like sails on a boat, the blades can also turn to catch the wind from every direction.

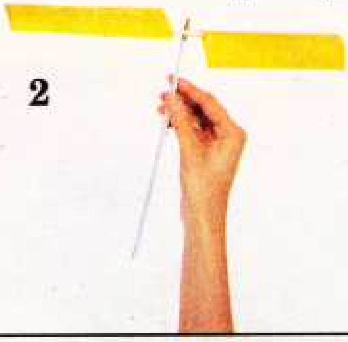
WORKING WINDMILL

1. To put the power of the wind to work, begin by making holes in a cardboard carton as shown. When you feed two straws through the holes, the bottom straw should angle upwards.

1



2. Make the blades for the propeller by following steps 1 to 3 of the whirligig project on page 30. This time the pieces of card will be 16cm by 12cm. Make the "tail" from the inside of a ballpoint pen.



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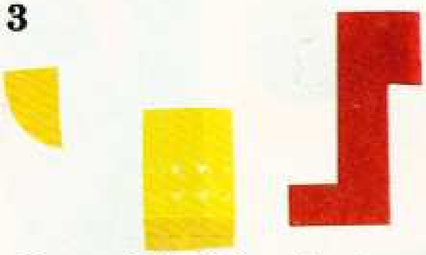
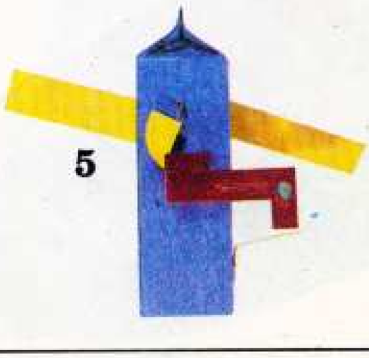


3. Your windmill is going to turn a cam which will push a hammer up. The hammer will strike a table. Make these pieces from stiff card as shown above.

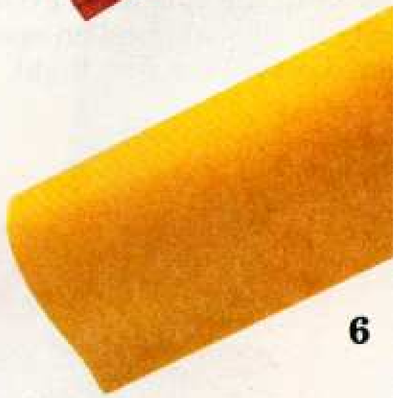
5. To put your simple machine together, push the propeller pen through the top straw. The cam wire feeds into this straw from the back.



5

4. Tape the "L" shaped wir to the yellow cam. Pierce a small hole in the centre of the hammer, push the othe wire through and tape it down. Now fold up the "hea of the hammer.

4



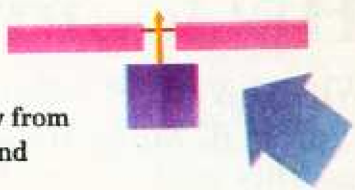
6

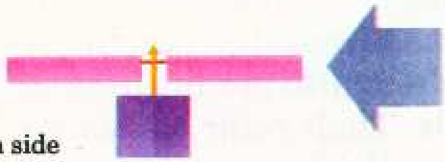
6. The hammer wire feeds into the high end of the bottom straw. Fix some plasticine onto the head. Tape on the table. Now blow on the blades and set your windmill spinning.

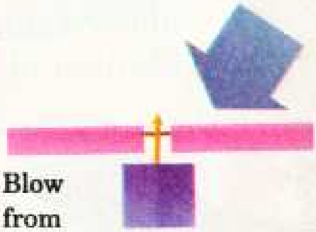
Bright Ideas

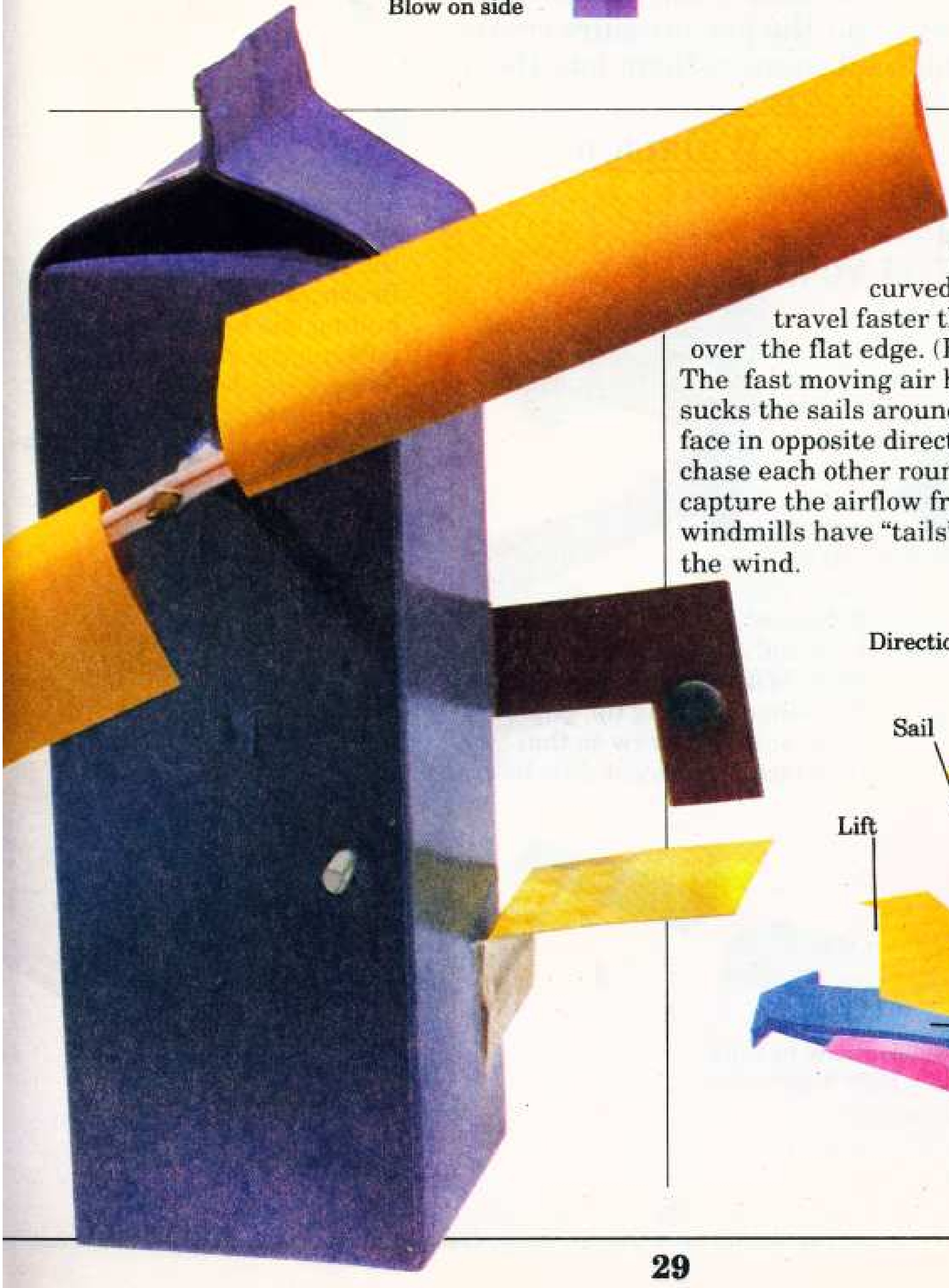
Blow on your windmill at different angles as shown here. Which direction makes the blades turn the most quickly and smoothly?

To make a simple paper windmill you need a square piece of card. Decorate it on both sides. Cut on a diagonal from each corner stopping one-third of the way from the centre. Fold down every other point and fix them in the centre with a pin. Push the pin through a bead before fixing it to a stick.



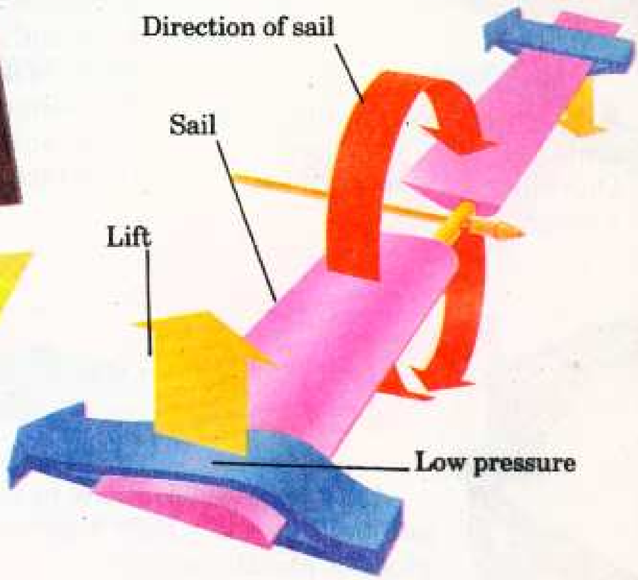






Why It Works

The wind passing over the curved edge of your sails has to travel faster than the wind passing over the flat edge. (Remember the aerofoil?) The fast moving air has low pressure which sucks the sails around. Because the aerofoils face in opposite directions, the blades forever chase each other round and round! To correctly capture the airflow from any direction, many windmills have "tails" which turn them to the wind.



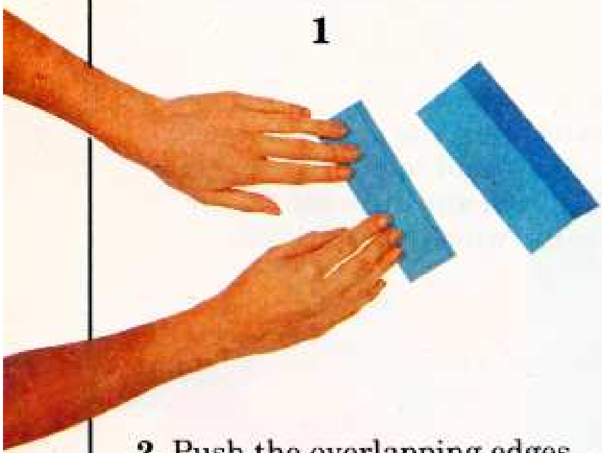
HELICOPTER ACTION

When an object falls through the air, the air pushes against it. Many trees have winged seeds which use this push to set them spinning. The wings are shaped like aerofoils, so that when they spin they stir up low pressure above them. Higher pressure from the blanket of air below slows their fall as they drift away from the "parent tree". Helicopters also get lift from twirling aerofoils. Their rotor blades spin so hard that the low pressure creates enough lift to carry them into the air.

WHIRLIGIG

1. Make two small aerofoils from two pieces of thin card 12cm by 8cm. Fold each piece with an overlap.

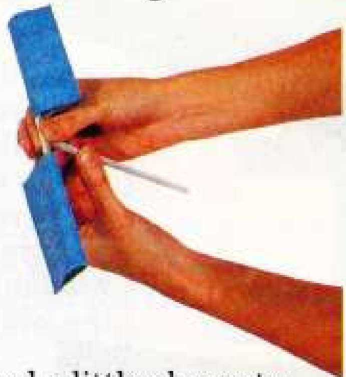
1



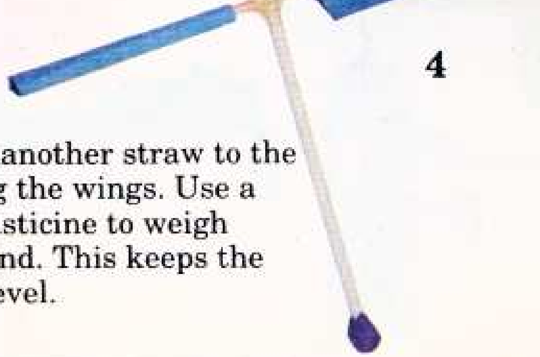
2. Push the overlapping edges and tape them together. One side will curve up like a wing.

2

3



3. Spread a little glue onto each end of a stiff straw or thin stick. With the curved side of the wings pointing up, glue them onto the straw so that they face in different directions.

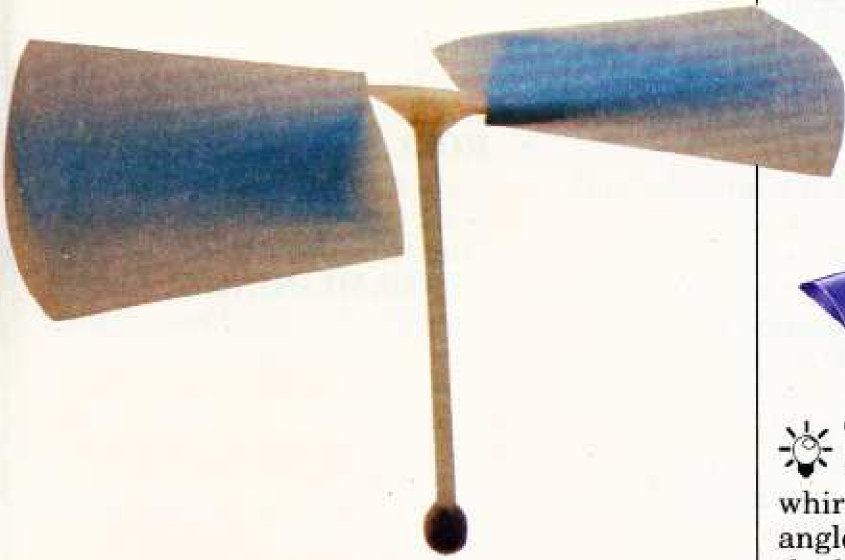


4

4. Tape another straw to the one holding the wings. Use a piece of plasticine to weigh down the end. This keeps the whirligig level.

5. To send the whirligig spinning, hold it between the palms of your hands. Brush your hands together, pulling one towards you and pushing the other away. As your hands come apart releasing the whirligig, watch it twirl as it flies.

5



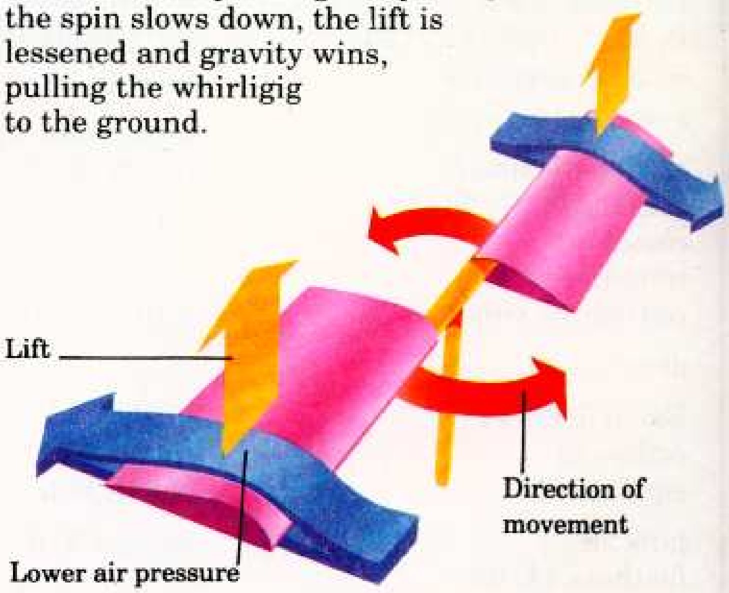
Bright Ideas

Make another, bigger whirligig by doubling the size of the blades. Do larger blades give more lift because it creates more low pressure? Therefore, do you have to spin it as hard as before?

Try fixing the wings of your whirligig at different angles. How does this affect the lift? Drop your whirligig. Does it spin as it falls?

Why It Works

As you twirl and release your whirligig, the wings give it lift. Their aerofoil shape cuts through the air smoothly but the "bulge" in the top stirs up the air, creating low pressure above. The air pressure beneath the wings is higher by comparison and therefore, pushes the whirligig skyward. A fast spin creates a big lift, greater even than the pull of gravity. But, as the spin slows down, the lift is lessened and gravity wins, pulling the whirligig to the ground.



Scientific Terms

AEROFOIL A surface like an aircraft wing, which is shaped to produce lift when air flows over and under it.
ATMOSPHERE The layer of air that surrounds the Earth.
BAROMETER An instrument that measures changes in air pressure and is used to predict the weather.
CONVECTION CURRENTS Movements of hot and cold air.
DRAG Air resistance, a force that holds back moving objects.
EDDIES Moving ripples of air.
FRICTION A force between two objects that rub together, which slows things down.
GRAVITY The pull of the Earth that gives things weight.
LATEEN A triangular sail that allows a boat to sail against the wind.
LIFT An upward force created by low pressure above.
OXYGEN A gas that makes up one-fifth of the air and is essential to life.
PITCH A turn upward or downward of the nose of an aircraft.
PRESSURE The force exerted on the surface of anything by the atmospher due to the gravitational pu the Earth.
ROLL A tipping of the win of an aircraft in which one wing tips upward and the other tips downward.
STREAMLINING Making object smooth and rounded that air flows easily over it surface.
THERMALS Currents of rising air.
YAW A turn from an aircra straight course.

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